Computer Science 271
Project `0111`
Due Wednesday, April 19

You will complete this project with the same partner with whom you completed Project `0111`. Both individuals are expected to contribute equally to all parts of the project, including the proofs.

1. Show the red-black trees that result after successively inserting the keys 41, 38, 31, 12, 19, and 8 into an initially empty red-black tree.

2. Prove that the longest path from a node x in a red-black tree to a descendant leaf has length at most twice that of the shortest path from x to a descendant leaf.

3. Implement a red-black tree template class. Your implementation should follow the same guidelines as the binary search tree and include the same public methods.

   You do not need to implement `remove`*, but you may do so for extra credit. No partial extra credit will be given; either it works or it doesn't.*

4. Write another template class implementation of a Dictionary ADT that inherits from your red-black tree template class. Your class should include the same methods as your `Dictionary` template classes in the previous projects.

5. Building on the comparison you performed in Project `0110`, compare the time it takes to insert all of the movies with the red-black tree, hash table, and binary search tree implementations. Explain your results.

To submit your project, include *all* your source files and a **single** PDF named `proj7_yournames.pdf` that combines a PDF of the above source files (created using `enscript`) with your answers to problems 1, 2, and 5.

If you do the extra credit in problem 3, please clearly indicate this in your PDF.